



vVICTORIA Console Development

Design and Fabrication of VICTORIA Console Emulations

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The scientific or technical validity of this Contract Report is entirely the responsibility of the contractor and the contents do not necessarily have the approval or endorsement of Defence R&D Canada.

Defence R&D Canada – Atlantic

Contract Report
DRDC Atlantic CR 2010-155
July 2011

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Abstract

This work describes the development of emulation designs of the Combat System equipment consoles currently fitted in the control room area of the VICTORIA Class submarines and the subsequent manufacture of the console emulations in accordance with those designs. Physical data and specifications of the actual consoles were gathered and emulations, to be constructed of wood, plastics and light metals, were designed based on that data. After DRDC Atlantic approval of the designs, the construction of the console emulations were completed as designed. This work will enable the vVictoria capability evaluation laboratory to move toward successful set-up and readiness to conduct experimentation on facets of new Combat System concept development including equipment capabilities, system integration, optimum equipment configurations and human factors.

Résumé

Le présent rapport porte sur le développement et la fabrication de modèles d'émulateurs des consoles de systèmes de combat actuellement installées dans la salle de contrôle des sous-marins de classe VICTORIA. Les émulateurs, faits de bois, de plastiques et de métaux légers, ont été fabriqués selon les données matérielles et les spécifications des consoles actuelles. RDDC Atlantique a approuvé les modèles, et ces derniers ont servi à la fabrication des émulateurs de console. Les présents travaux permettront la mise sur pied du laboratoire d'évaluation de la capacité vVictoria et assureront que celui-ci est prêt pour les essais de nouveaux concepts de système de combat, visant notamment les fonctions de l'équipement, l'intégration du système, les configurations optimales du système et les facteurs humains.

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Executive summary

vVICTORIA Console Development: Design and Fabrication of VICTORIA Console Emulations

Keith Bowden, Earl Gosse; DRDC Atlantic CR 2010-155; Defence R&D Canada – Atlantic; July 2011.

Introduction: This work focuses on the design, specification and manufacture of VICTORIA Class Submarine Combat System console physical emulations. This project is part of an overarching project advanced by the Maritime Command and Control Concept Development (MC2CD) group at DRDC ATLANTIC to develop a laboratory replication of the Control room area of the VICTORIA Class submarine for experimentation in future Combat System Concepts. The work was carried out by ADGA Group Consultants Ltd in liaison with the MC2CD group.

Results: The design and specification of 11 console emulations were completed, followed by manufacture of 10 consoles, of which there were 7 copies of the Multifunction Console. Mockups were completed of the Aft-Sonar Rack, Chart table, Multi-Function Console and the One-Man Console was partially completed. A survey of commercially available user interfaces (keyboards, switches etc.) available to provide hardware emulation to actual console interfaces was completed. Key visible operator controls were installed in the primary Multi-function consoles.

Significance: The vVictoria is a prototype for the development of a C2 capability evaluation laboratory and will provide the necessary “stage area” for human factors experimentation on new concepts for submarine C2. This contract completed two critical parts of the development of vVictoria; first it provided designs for the mockup of all major control centre consoles, and secondly it provided the vVictoria with sufficient infrastructure for the project to demonstrate the expected end capability. While this contract did not cover the implementation of software or complete implementation of interfaces it demonstrated the viability of this approach and identified a number of important issues for future console emulation. In particular, the need to emulate in software the functionality of some types of hardware switches.

Future plans: The remainder of the consoles will be completed, outfitted and installed in the vVictoria lab as required for experimentation.

Sommaire

vVICTORIA Console Development: Design and Fabrication of VICTORIA Console Emulations

Keith Bowden, Earl Gosse; DRDC Atlantic CR 2010-155; R & D pour la défense Canada – Atlantique; juillet 2011.

Introduction : Les présents travaux portent sur les spécifications, la conception et la fabrication d'émulateurs physiques des consoles de systèmes de combat des sous-marins de classe VICTORIA. Ces travaux font partie d'un grand projet du Groupe d'élaboration de concepts maritimes de commandement et de contrôle de RDDC ATLANTIQUE, qui vise à émuler en laboratoire la salle de contrôle d'un sous-marin de classe VICTORIA afin de mettre à l'essai de futurs concepts de systèmes de combat. Les travaux ont été exécutés par ADGA Group Consultants Ltd de concert avec le Groupe.

Résultats : On a conçu les modèles de 11 émulateurs de console et rédigé les spécifications, puis fabriqué 10 consoles, dont sept reproductions de la console multifonction. Nous avons conçu des maquettes du bâti sonar arrière, de la table à cartes, de la console multifonction, et une maquette partielle de la console à un seul pupitre. Nous avons étudié les interfaces utilisateurs commerciales (claviers, commutateurs et autres) disponibles pour fournir l'émulation matérielle aux interfaces de console actuelles. Des commandes opérateur clés visibles ont été installées dans les principales consoles multifonction.

Portée : Le vVictoria est un prototype pour le développement d'un laboratoire d'évaluation de capacité de contrôle et de commande et sera la « zone d'essai » nécessaire à l'expérimentation des facteurs humains sur de nouveaux concepts de fonctions de contrôle et de commande des sous-marins. Le présent contrat a mis fin à deux étapes essentielles du développement de vVictoria : il a permis la conception de modèles pour la maquette de toutes les principales consoles de contrôle centrales, et il a fourni une infrastructure suffisante à vVictoria pour faire état de la capacité finale prévue du projet. Même si le contrat ne portait pas sur l'implantation de logiciels ni l'achèvement de l'implantation d'interfaces, il a démontré la viabilité de cette méthode et a permis de cerner plusieurs problèmes importants quant à l'émulation de console future. Tout particulièrement, le besoin d'émuler par logiciels la fonctionnalité de certains types de commutateurs.

Recherches futures : Les autres consoles seront terminées, outillées et installées dans le laboratoire de vVictoria selon les besoins des essais.

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1 Introduction

1.1 Subject of Report

This work focuses on the design, specification and manufacture of VICTORIA Class Submarine Combat System console physical emulations. This project is part of an overarching project advanced by the Maritime Command and Control Concept Development (MC2CD) group at DRDC ATLANTIC to develop a laboratory replication of the Control room area of the VICTORIA Class submarine for experimentation in future Combat System Concepts. The work was carried out by ADGA Group Consultants Ltd in liaison with the MC2CD group.

1.2 Outline of Report

This report is structured with an introduction covering some of the background information and motivation for the work, the methods used, results, analysis of results, along with a summary covering conclusions and recommendations. Much of the introductory information for this report is based on background material provided by DRDC Atlantic.

1.3 Background

The Canadian Submarine operational community, much impressed by the development capabilities offered by land based development facilities operating and in use by the United Kingdom and Australia, joined in discussions with DRDC Atlantic and the research community to determine the feasibility of building such facility within Canada. The vVictoria Shell laboratory project initiated by DRDC Atlantic came in to being as a result of this continuing dialogue. The vVictoria Shell project itself will provide the basic laboratory. As a physical replication of the Control Room area of the submarine it creates the “stage” for experimentation into many human factor issues associated with submarine command and control as well as the capability for concept evaluation and system integration and development activities. By making a full functional equivalent of the operational system available to capability developers, substantial portions of the development problem can be investigated and tested prior to transition to the operational fleet. In order for the vVictoria Shell space to fulfil its purpose it must have replications and emulations of the equipment normally fitted within the area so that operator actions and interactions can be observed, this console emulation project is one step in providing the emulations needed.

1.4 Motivation for vVICTORIA Consoles

The addition of the console emulations to the Shell will move the concept of the laboratory a major step closer to operational fruition. It is this desire to begin investigating many hitherto unanswered questions, many of them surrounding command and control team human factors issues that have been the motivating factor for the console emulation project.

1.5 Rationale for Consoles

In order that the vVictoria Laboratory is able to meet the varied experimentation and assessments that are anticipated as future capability needs, one of the most fundamental requirements of the vVICTORIA Shell is that the Combat System installations, while reflecting the current fleet fit, offer the maximum possible level of flexibility; flexibility in physical form and configuration, in system component location, and in software applications and functionality.

The use of real system hardware and software would be not only prohibitively expensive but also inflexible in all of the aspects of installation and use mentioned above. By using a replica of the consoles and emulating their functionality through software based models the overall cost is minimized and flexibility and ease of change are possible to a level required for successful experimentation.

2 Methods used

2.1 Background

The contract for the design and build of the vVICTORIA consoles was divided into two parts. The first part being also comprised of two Phases: Phase 1 encompassing the design and cost estimations for all the specified consoles, Phase 2 covering the construction of as many of the approved console designs as the part 1 budget allowed. In the execution of Part 1 of the contract two multi-function console emulations were built and delivered. In the second part of the contract, (Part 2 or Phase 3), the remaining consoles were to be constructed to the maximum that the contract budget would allow.

In order to complete the design of the console replicas a detailed knowledge of their physical appearance and dimensions was clearly essential; this was garnered through the study of an extensive catalogue of photographs taken of the consoles in situ in a VICTORIA Class submarine. This photograph study was combined with detailed measurements of the consoles physical dimensions taken from the actual consoles fitted for training purposes in the model rooms of the Submarine Training Department at the Canadian Forces Naval Operations School (CFNOS) in HMCS Stadacona.

2.2 Design Work

The design work started with reviewing all of the information passed to ADGA by DRDC Atlantic, which included a list of all consoles, numerous photographs of onboard console fits, 3D photos, a March 2009 slide show depicting all of the Control Room equipment along with names, and 3D SketchUp models that could be viewed and manipulated with SketchUp 7.1 available from Google. Despite the volume of data available, seemingly sufficient to commence design of the consoles, such was not the case and it was found necessary to research other sources of information to obtain the physical data required to facilitate the emulation design to the accuracy required. This additional research included a visit to TWS-1, the Submarine School Tactical Weapons Maintenance Trainer, which was arranged by DRDC.

Two thrusts were pursued in the design work, one being the physical design drawings and the other being the research necessary to search out suitable components that would represent approximate functionality to the real equipment at an affordable price. The drawing design work was carried out using AutoCAD LT 2010 and formatted to be suitable for printing on 11x17 inch paper. Accumulation of suitable components was carried out primarily through an extensive Internet search. The design drawings are included in this report as Annex A and the AutoCAD Files are also included in the soft copy (CD) version of the report.

2.3 Construction

The Construction of the consoles was carried out by two local carpenters and Weldpro, a local welding company. Both carpenters had their own workshops with adequate space and equipped with all the tools necessary for the manufacture and construction of the console shells. Weldpro fabricated one of the sonar racks during the second phase of the contract and one of the carpenters

fabricated two Multi-function consoles (MFC's) without painting or electrical components. The Subcontractors were provided with all the relevant console design drawings and were advised on drawing interpretation and material selection throughout the construction and painting process by the ADGA project engineers and designers.

3 Results

During the vVictoria Console Project's third phase the following work was carried out:

- a. The two original MFC's previously delivered during the first part of the contract (Phase 2 – post design), were painted and fitted with casters and made available to DRDC for a demonstration made to several senior Naval Staff members after which they were returned to ADGA to be fitted with keyboards etc.
- b. The sonar rack was painted and fitted with casters and delivered to DRDC.
- c. An additional five MFC's were fabricated, painted and fitted with casters.
- d. Three of the MFC's were fitted with electrical components such as keyboards, trackballs, keys, switches, power bars, USB's, etc.
- e. the plot table was fabricated and painted.
- f. the One Man Control (OMC) was fabricated and painted (minus PVC and fittings).

The primary construction material used throughout was 3/4" paint grade birch plywood and PVC with the exception of the sonar rack, which was fabricated of aluminum. Some of the completed consoles and detail are depicted in the following pictures.



Figure 1 Three Multi Function Consoles (MFC's) with keyboards and trackballs fitted.



Figure 2 Internal fitment of power-bar and electrical components to MFC



Figure 3 Placement of keyboard and trackball for MFC

All AutoCAD Drawing files, along with actual drawings and parts lists were supplied to DRDC Atlantic as stated above together with specification sheets for all components.

The parts listings which include price at time of project completion, source, part numbers and suppliers are included in this report as Annex B.

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4 Analysis of Results

The intent of this section is to highlight what are considered to be the more significant of the lessons learned during the execution of the project.

4.1 Design

For the drawings, the selection of AutoCAD LT 2010 was a good choice. This was the latest version of AutoCAD available at the time of project start up and has many new productivity features; however, since it was the "LT" version it lacked the 3D capability of the full AutoCAD package, the lack of this capability was considered acceptable as 3D rendering of these drawings was unnecessary. However, selected drawings were completed in isometric view which provides a 3D perspective.

DRDC provided an abundance of information and data to complete the design of the consoles and most of it was used to some extent. Unfortunately the data did not provide the dimensional accuracy that was required for some of this work. To take the Multi Function Consoles' (MFC's) as an example, the 3D sketches, meant for SketchUp application, depicted flat sides, flat top and flat back. If the MFC's had been constructed to those dimensions then they would not have emulated the real consoles to the level of fidelity required, appearing unrealistic to experienced submariners and additionally would, in all likelihood, not have fitted properly in the control room mock up. The MFC's were assigned a high priority as they are expected to be the console of choice for all primary Combat System operator positions in the future. In view of this, the ADGA team took considerable pains to determine the physical characteristics of the console to a high degree of accuracy. Reliable information was gathered from various other sources beyond that which was provided by DRDC. In addition, a trip to the TWS-1 was arranged by DRDC which enabled the ADGA team to take accurate measurements directly from the various consoles. This activity applied primarily to the MFC's, the plot table and sonar consoles. The OMC is not installed in the TWS-1 hence first hand dimensional data was not available for this console. For the OMC, reliance was put on the SketchUp data provided by DRDC.

To summarize the accuracy of information gathered from various sources, it can be said that the accuracy of the MFC's physical dimensions are within two or three millimetres because they are based on accurate information gathered from multiple sources and because direct measurements were taken at the TWS-1. Some of the other measurements such as those of the OMC can be considered to be accurate only within two or three centimetres because reliance was totally on the SketchUp dimensions provided. Although SketchUp can be considered to be only of medium accuracy it was of tremendous benefit in cases where direct measurements could not be obtained.

A significant part of the design task was the identification of visible operator controls, switches and indicators. This task was carried out in large part by painstakingly searching the Internet, starting where possible with the Original Engineering Manufacturer (OEM) and then, where necessary, expanding the search to other manufacturers until an equivalent or substitute was found. The search was often made more difficult by lack of detailed knowledge of the total functionality of the component.

4.2 Fabrication

With the exception of the Sonar Rack, the consoles were fabricated from 3/4" paint grade birch plywood, and where necessary faced with 1/4" PVC to facilitate fitment of components. One sonar rack was fabricated from aluminum. The choice of 3/4" hardwood plywood proved to be a good one because it was reasonably affordable and provided the structural integrity necessary for this application. The thickness of the plywood enabled edge screwing/nailing and gluing without the need for other structural elements. The PVC, at 1/4" thickness was a good choice for facing the consoles where required because it is thick enough to provide adequate structural rigidity and at the same time allowed the detailed cutting required for mounting components. The use of aluminum for the sonar rack was an obvious choice because of its open frame structure. It has a plywood bottom to allow for the fitting of casters. The manufactured rack under this contract is very similar to the actual "onboard" rack with the exception of the casters.

Due to budgetary constraints, not all of the consoles were completed under this contract.

For painting, an oil based gloss Tremclad was selected for application over a latex primer. The use of oil based paint provided the hardest finish, but with the required application of multiple coats, the drying consumed more time. For the final layer of painting a dryer was mixed in the paint which reduced drying time to about 5 hours versus at least 24 hours without dryers.

4.3 Future Work

Future work could include any or all of the following:

- a. Completion of the remaining consoles,
- b. Refinement of some console design drawings to incorporate any requested changes or modification and/or to increase dimensional accuracy should this be considered necessary for individual consoles,
- c. Further sourcing of suitable and affordable electrical components, and installation in the consoles, and
- d. Investigation into and incorporation of simulation/stimulation capability to further closely resemble real equipment. An example of this enhanced simulation capability might be to implement quality simulation screens that offer real world look and feel that greatly enhance a user's experience.

5 Summary

5.1 Summary of Results and Analysis

The purpose of this report was essentially to describe the work carried out by ADGA in support of the DRDC Atlantic contract to construct submarine control room mockup consoles for the purpose of testing out human factors and new equipment concepts.

5.2 Conclusions

The following conclusions are offered:

- a. The choice of materials, mainly paint grade plywood, aluminum and PVC, was suitable for the fabrication of consoles under this contract;
- b. The choice of AutoCAD LT 2010 was appropriate for the design;
- c. The cost of the consoles increases very quickly with increased conformity to onboard equipment;
- d. Identification of operator control, indicator and switch components and/or substitutes would have been facilitated by specifications of individual component functions;
- e. Taking first hand direct measurements are often necessary to acquire or confirm equipment dimensions;
- f. Completing all consoles with all features was difficult to achieve within the available funds and Schedule;
- g. Further work can be done to complete all consoles with the desired features; and
- h. This endeavour is seen to be potentially very beneficial to Canadian submariners.

5.3 Recommendations

The following recommendations are offered:

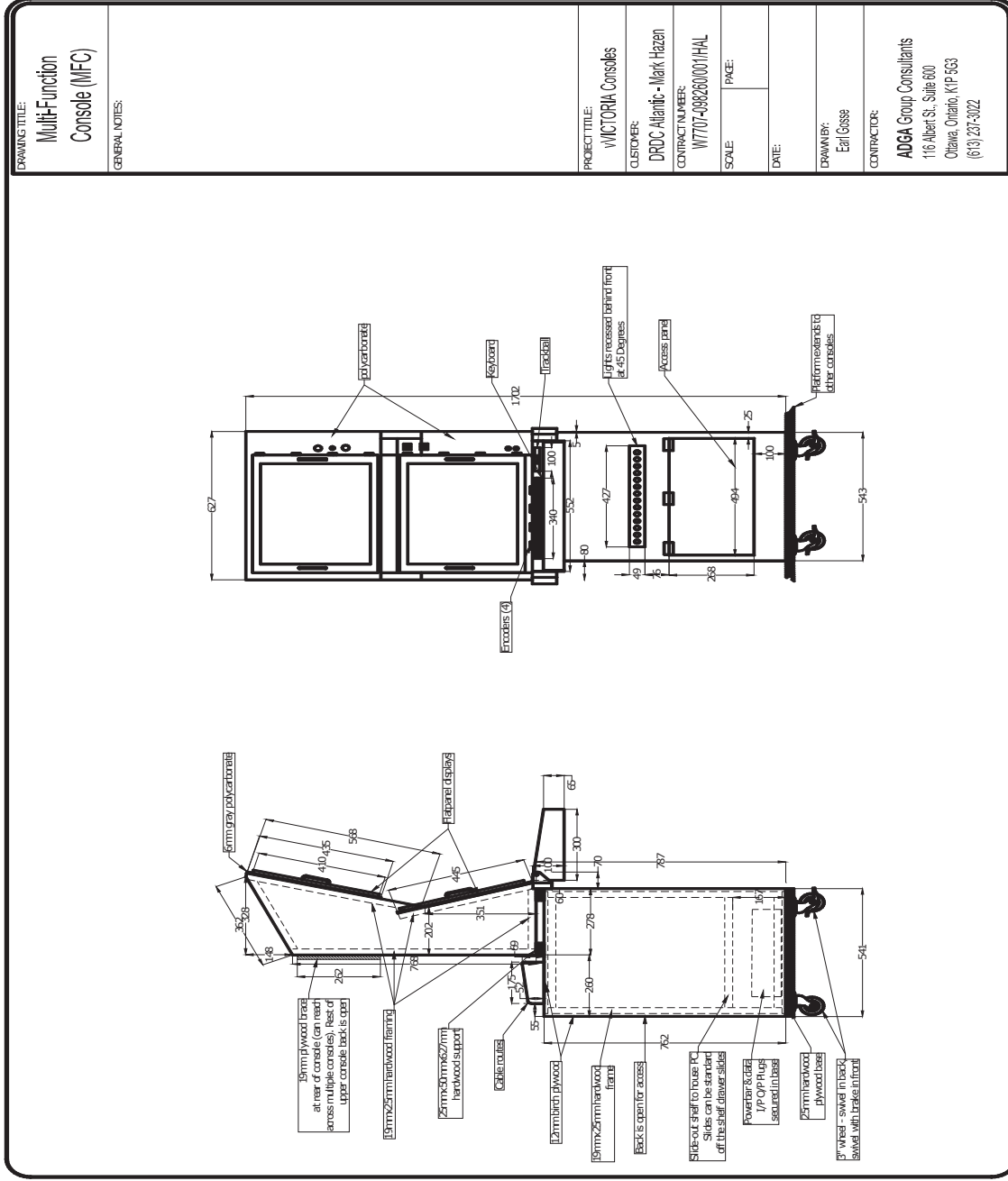
- a. Continued work to complete and/or enhance the consoles should follow the same material choices;
- b. Addition of electronic components should be reconciled with the available budget;
- c. Any design work associated with mock ups of real equipment should include site visits to confirm measurements;
- d. All console operator control functions be defined;

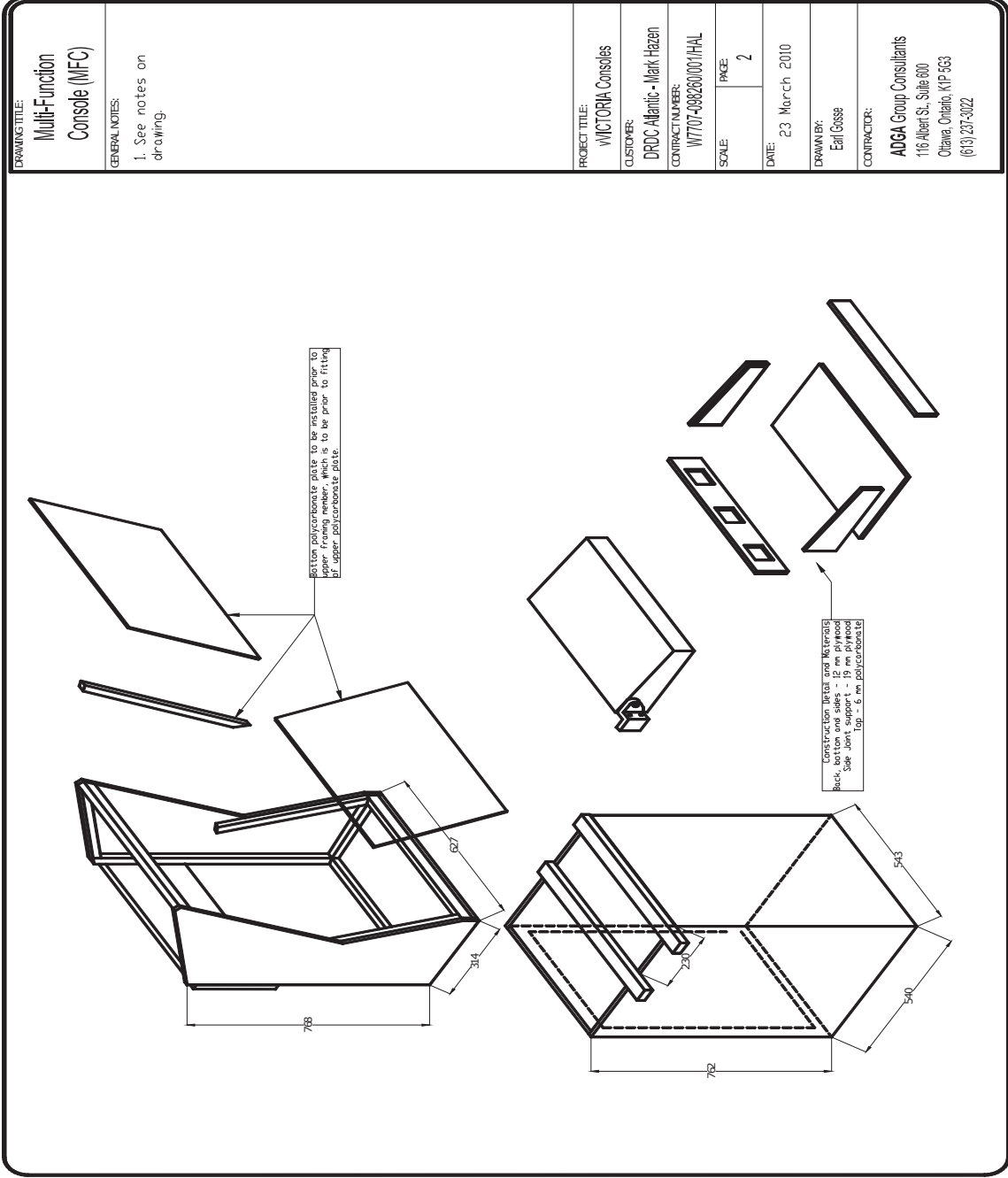
- e. This work should be progressed further to achieve the desired outcome; and
- f. Canadian submariners should continue to be consulted for their input.

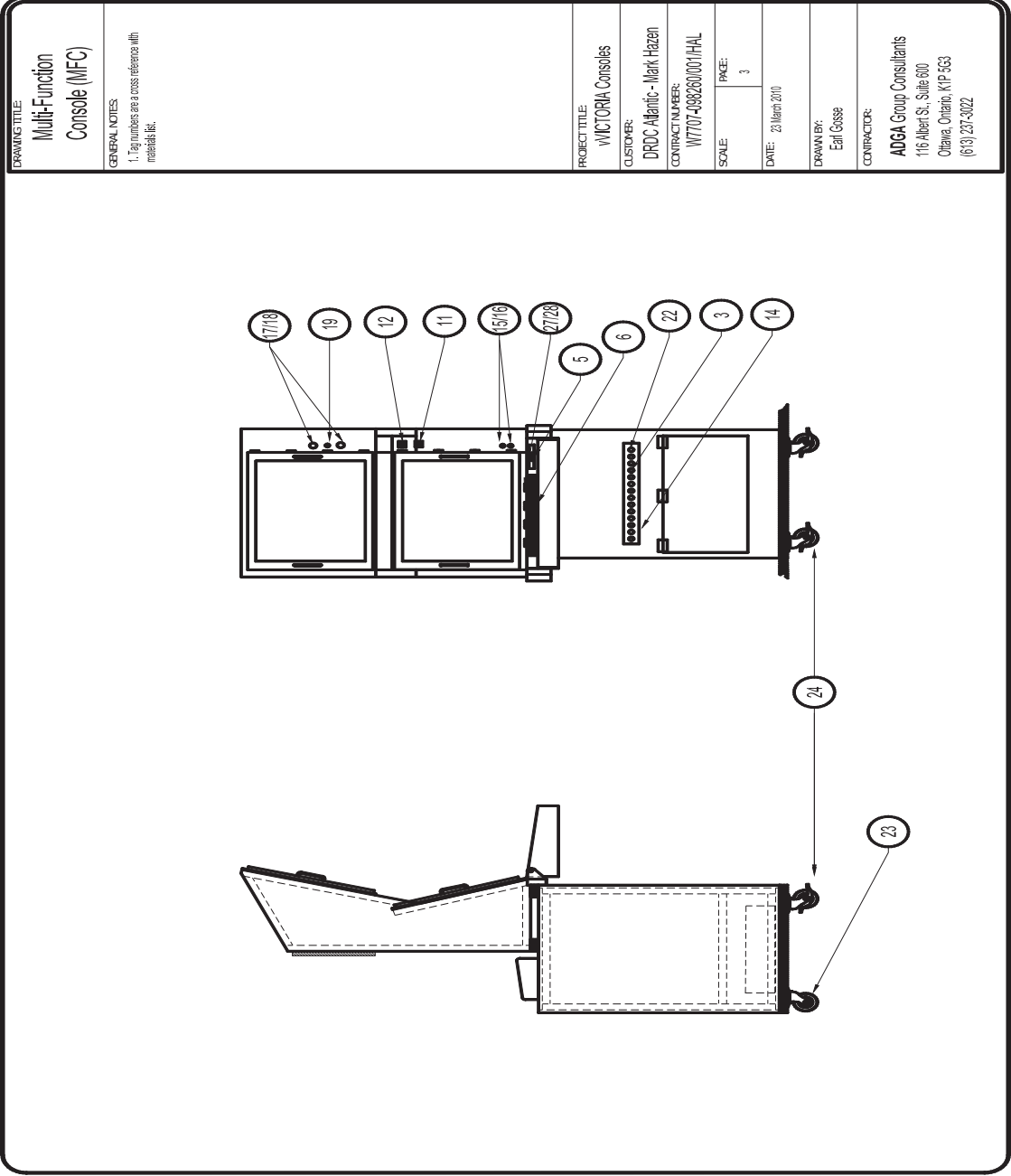
Annex A Design Drawings

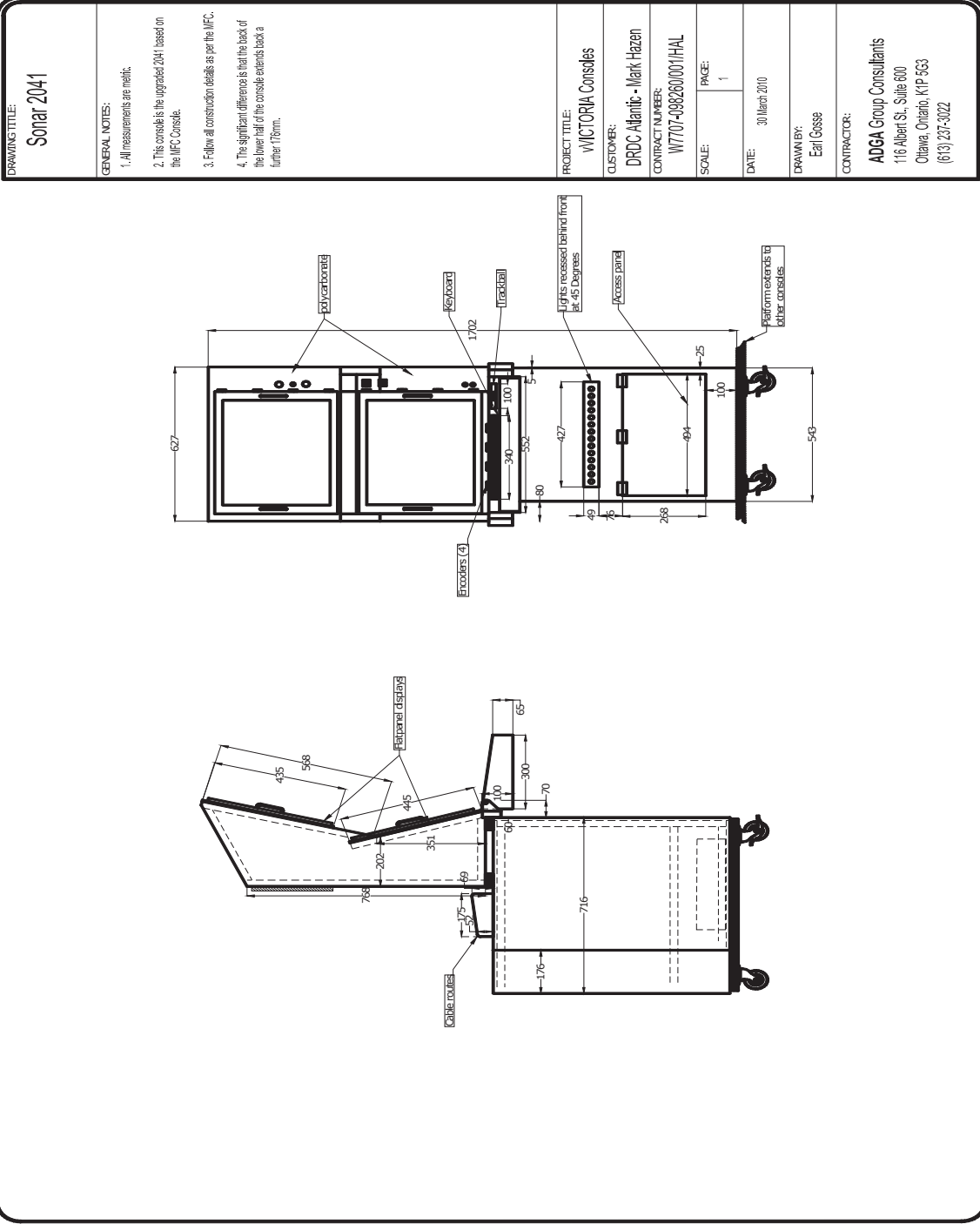
This annex comprises the drawings of all consoles specified under this contract. All drawings were delivered to DRDC in AutoCad Lt 2010 on a CD. Because of the small size of the drawings below it is not recommended that they be used for construction, but rather the drawings supplied in the CD should be printed out on sheets not smaller than 11" x 17".

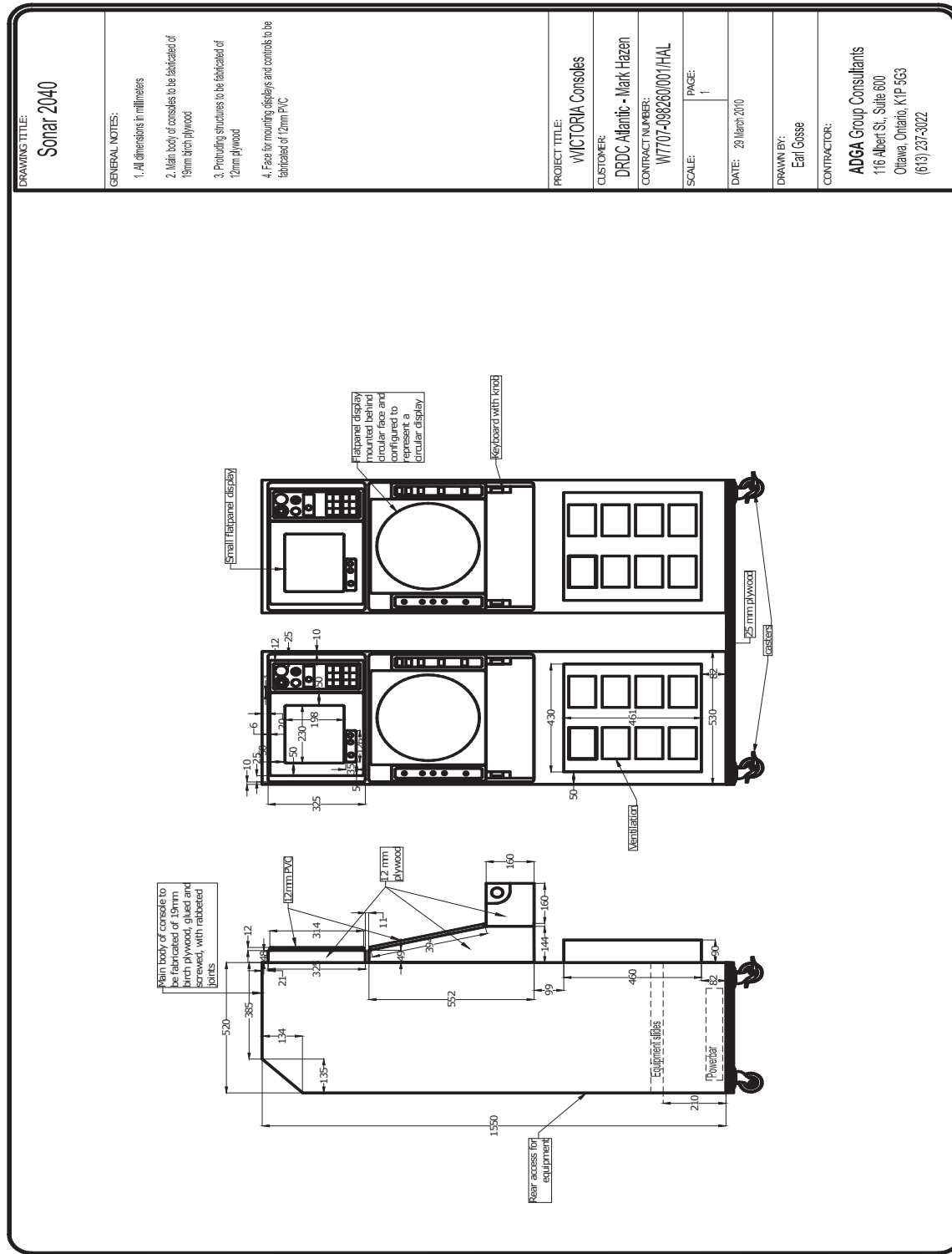
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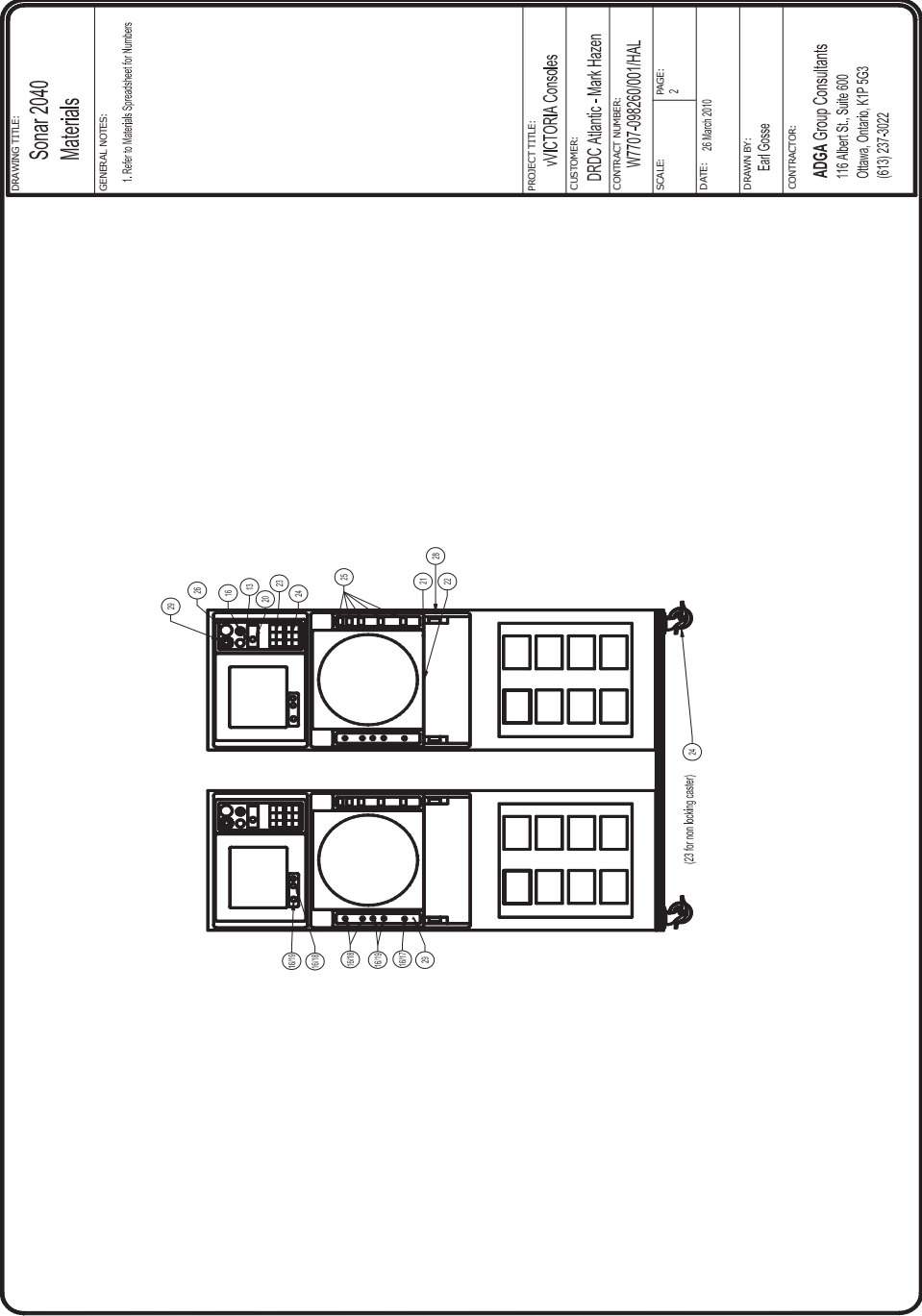


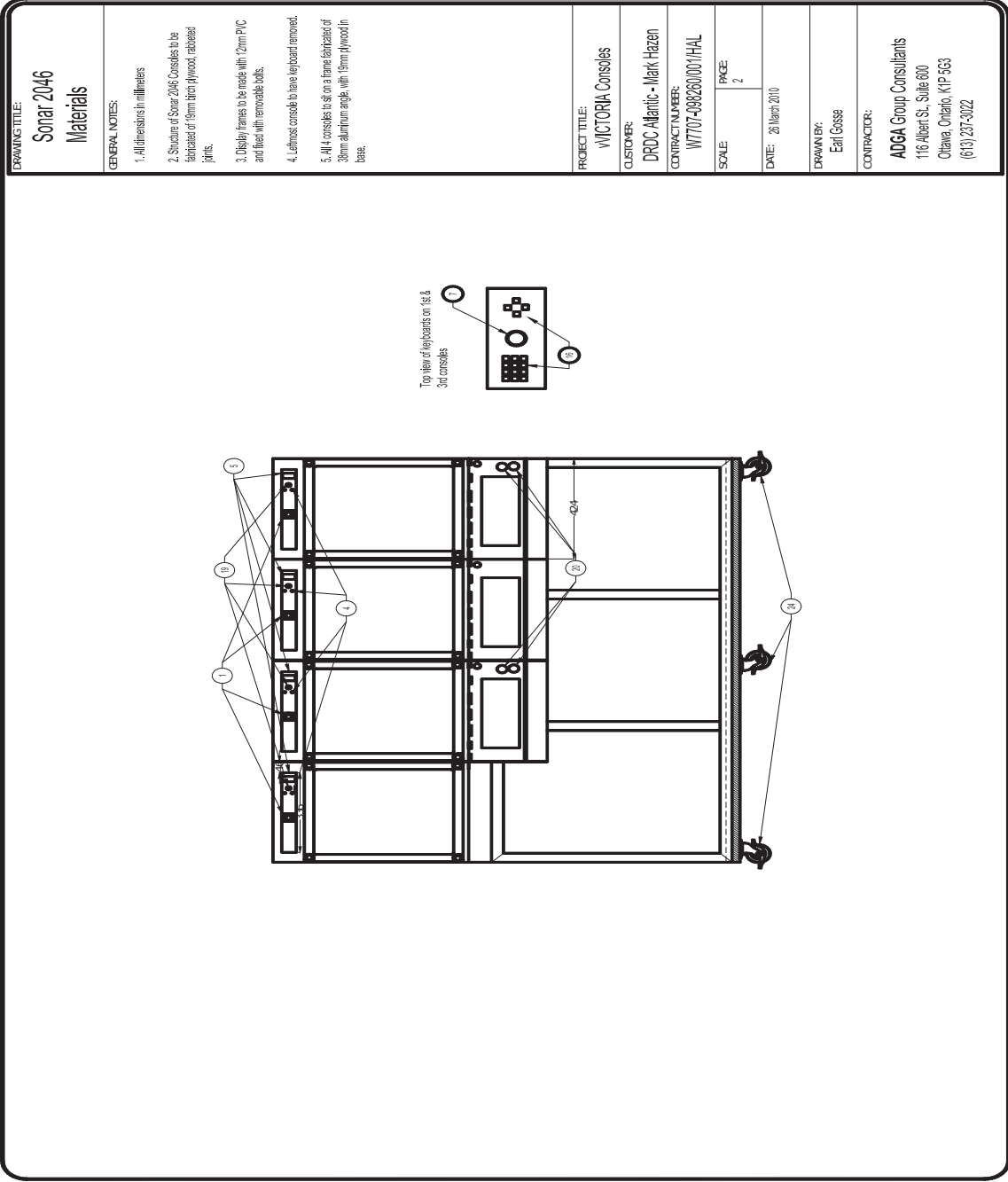












Plotting Table

GENERAL NOTES:

1. All dimensions in millimeters

PROJECT TITLE:

VICTORIA Consoles

CUSTOMER:

DRDC Atlantic - Mark Hazen

CONTRACT NUMBER:

N7707-098260/001/HAL

SCALE:

PAGE:

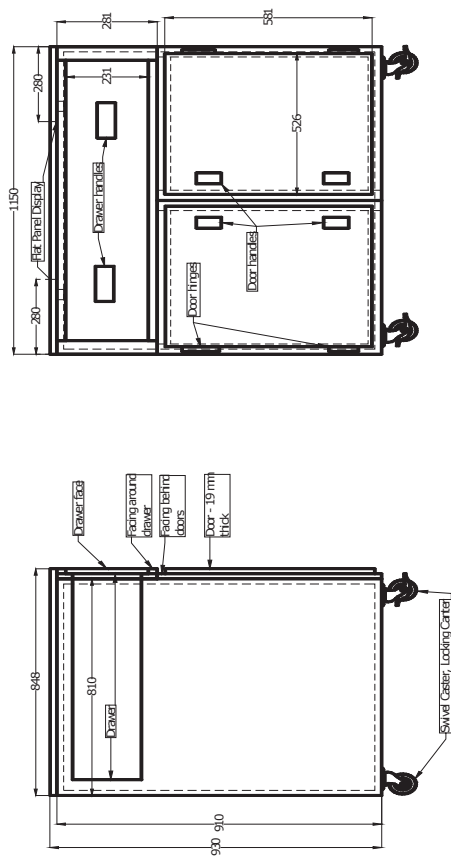
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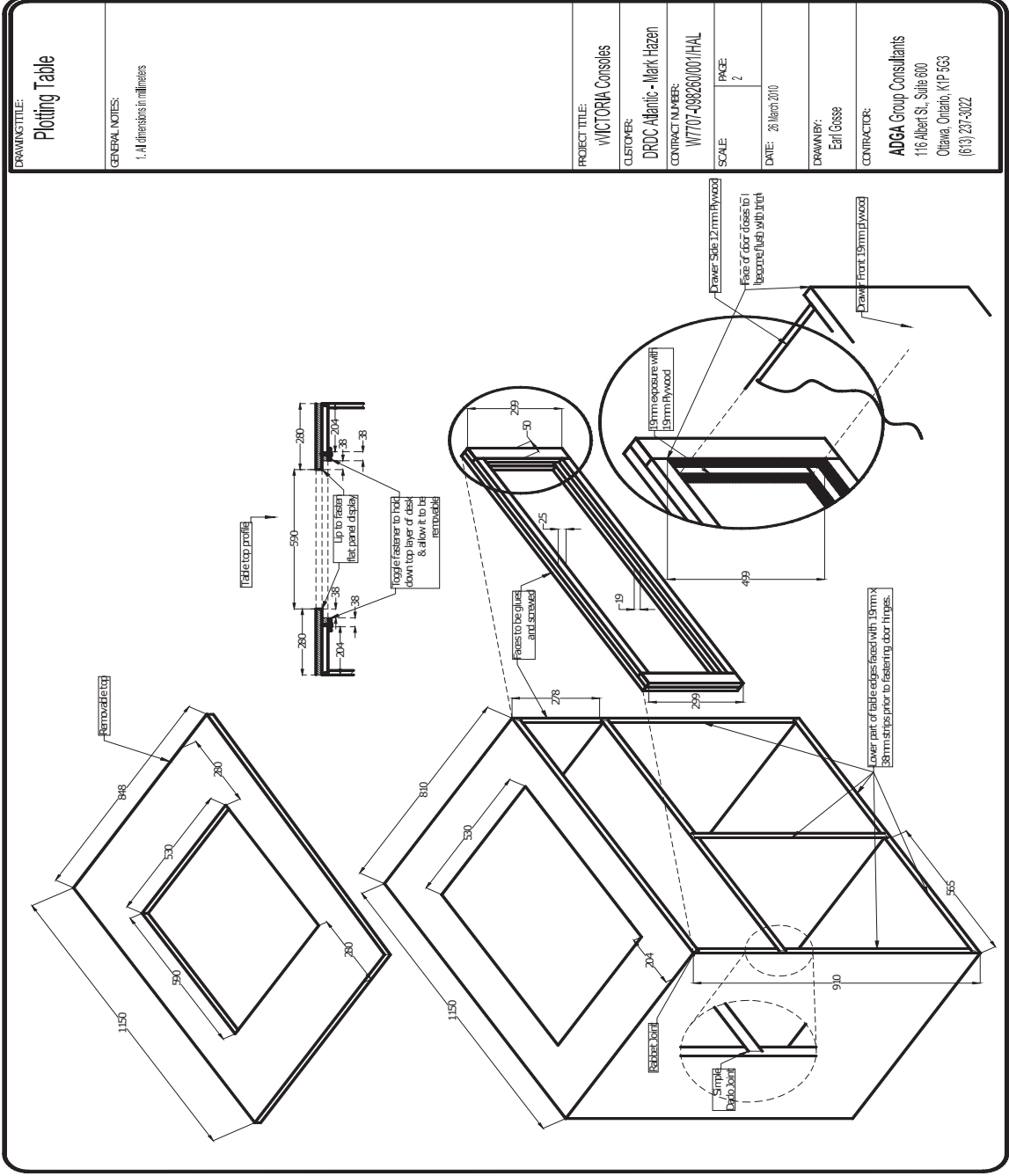
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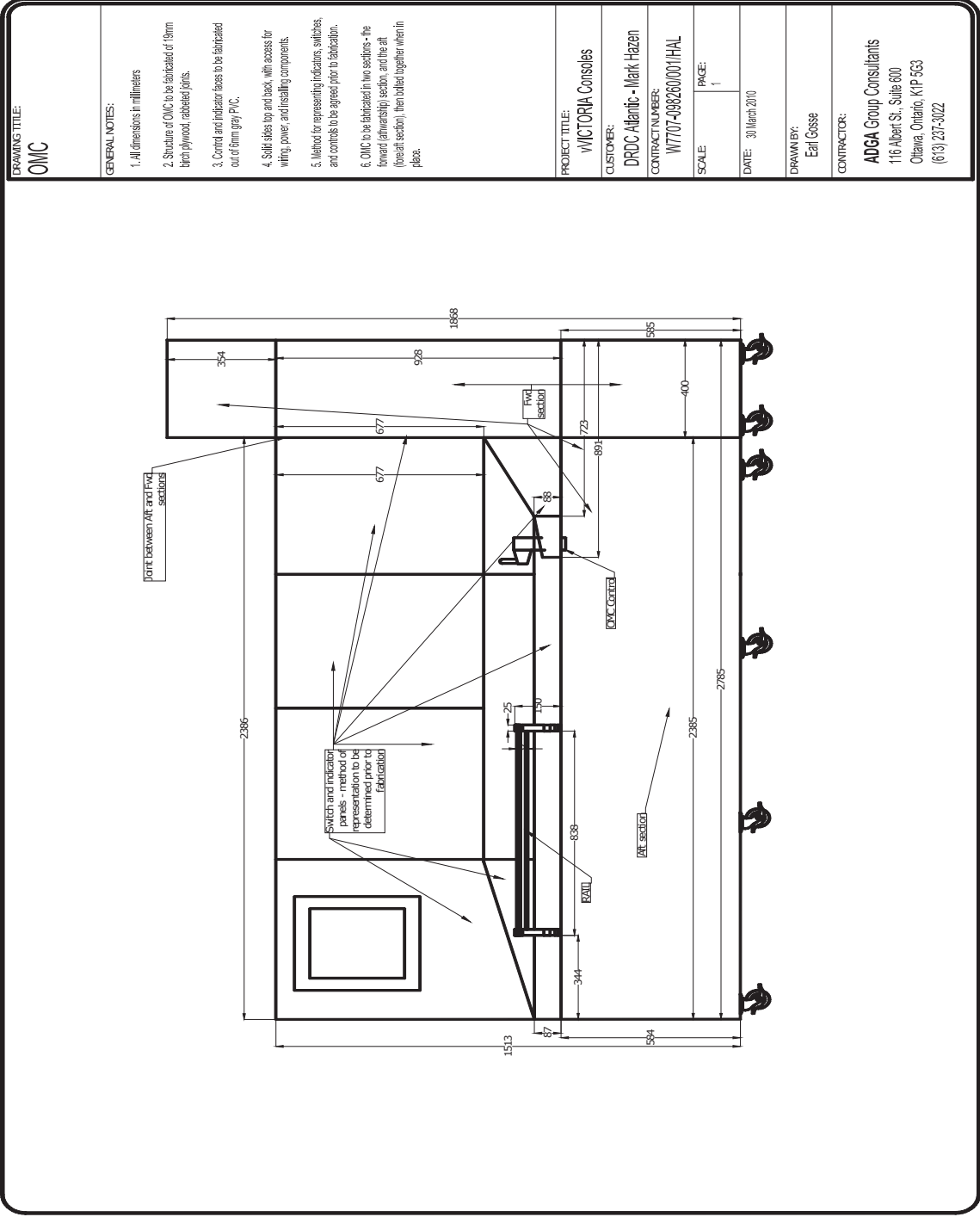
Earl Gosse

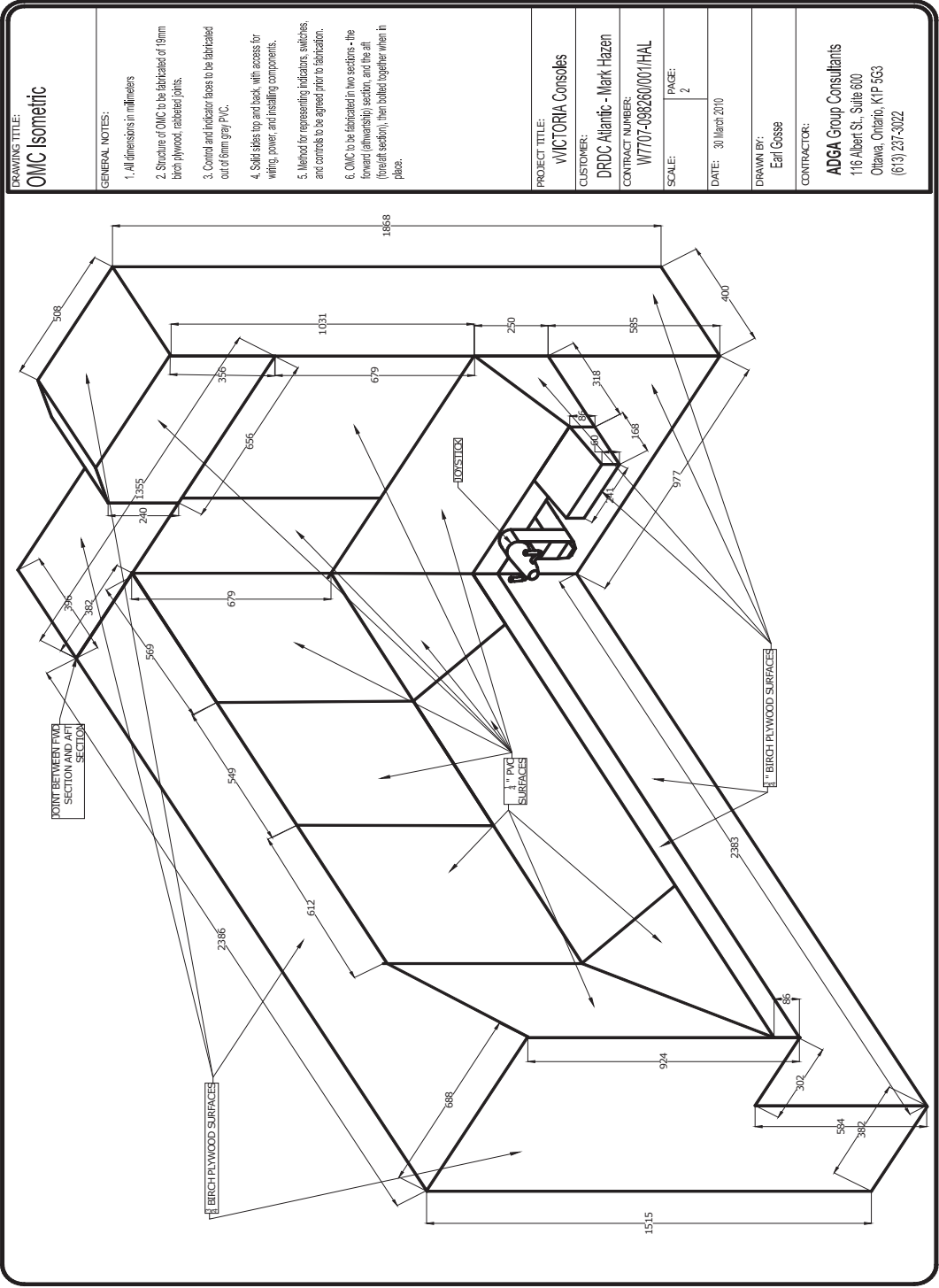
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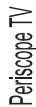
ADGA Group Consultants
116 Albert St., Suite 600
Ottawa, Ontario, K1P 5G3
(613) 237-3022











GENERAL NOTES:

1. All dimensions in millimeters
2. Structure of rack to be fabricated of 19mm birch plywood, rabbeted joints.
3. Face to be fabricated out of 12mm plywood.
4. Solid sides top and back.

PROJECT TITLE:

vVICTORIA Consoles

CUSTOMER:

DRDC Atlantic - Mark Hazen

CONTRACT NUMBER:

W7707-098260/001/HAL

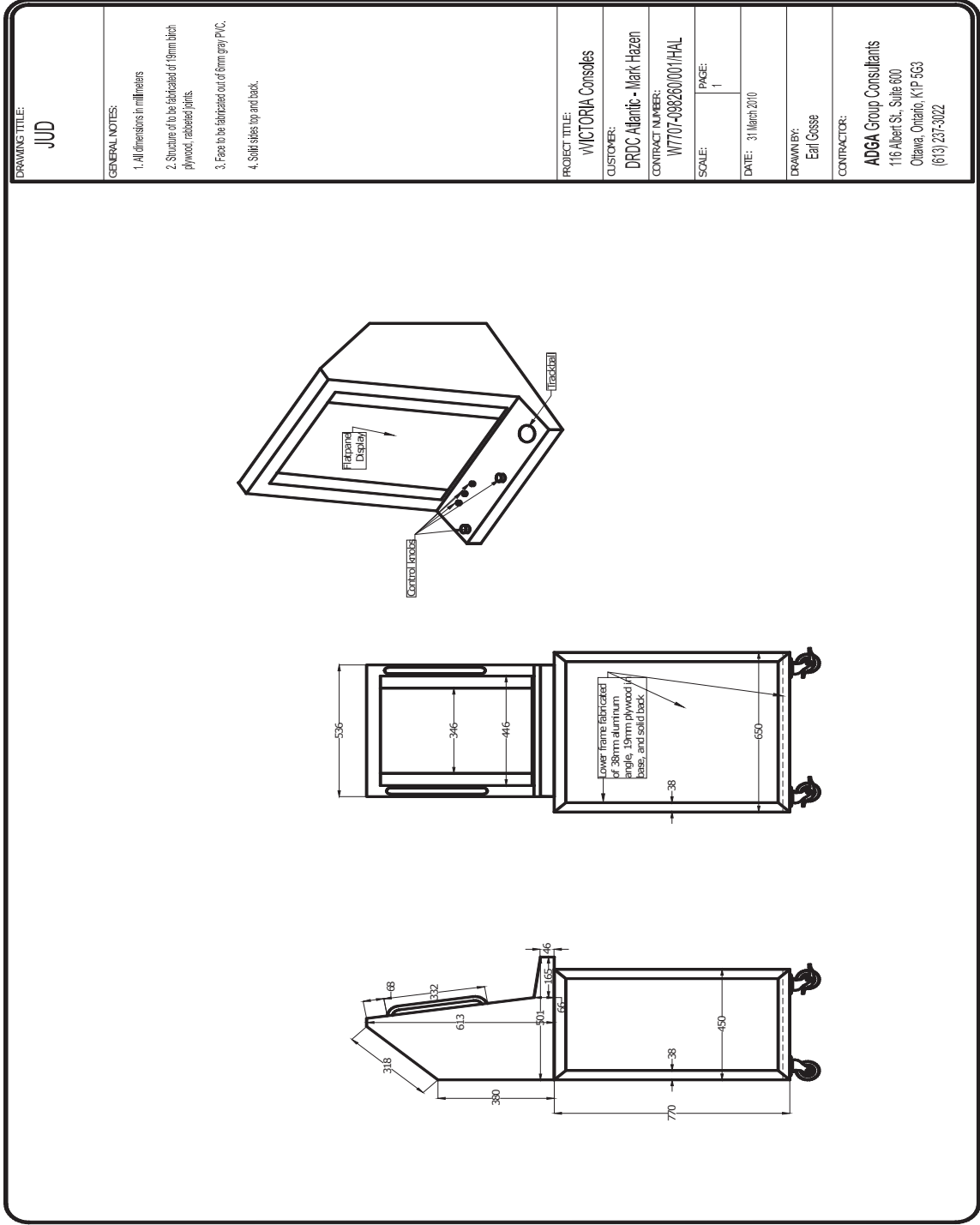
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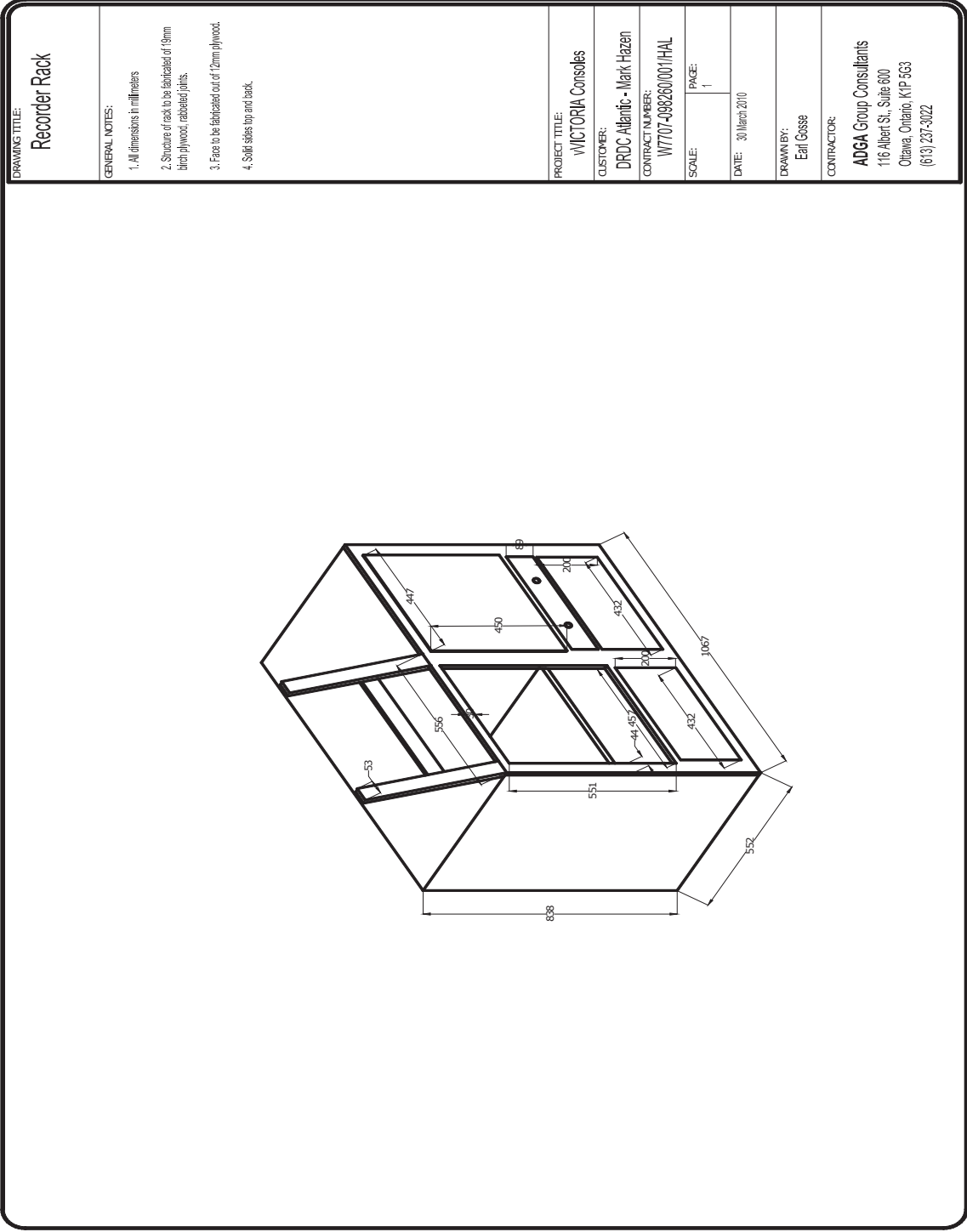
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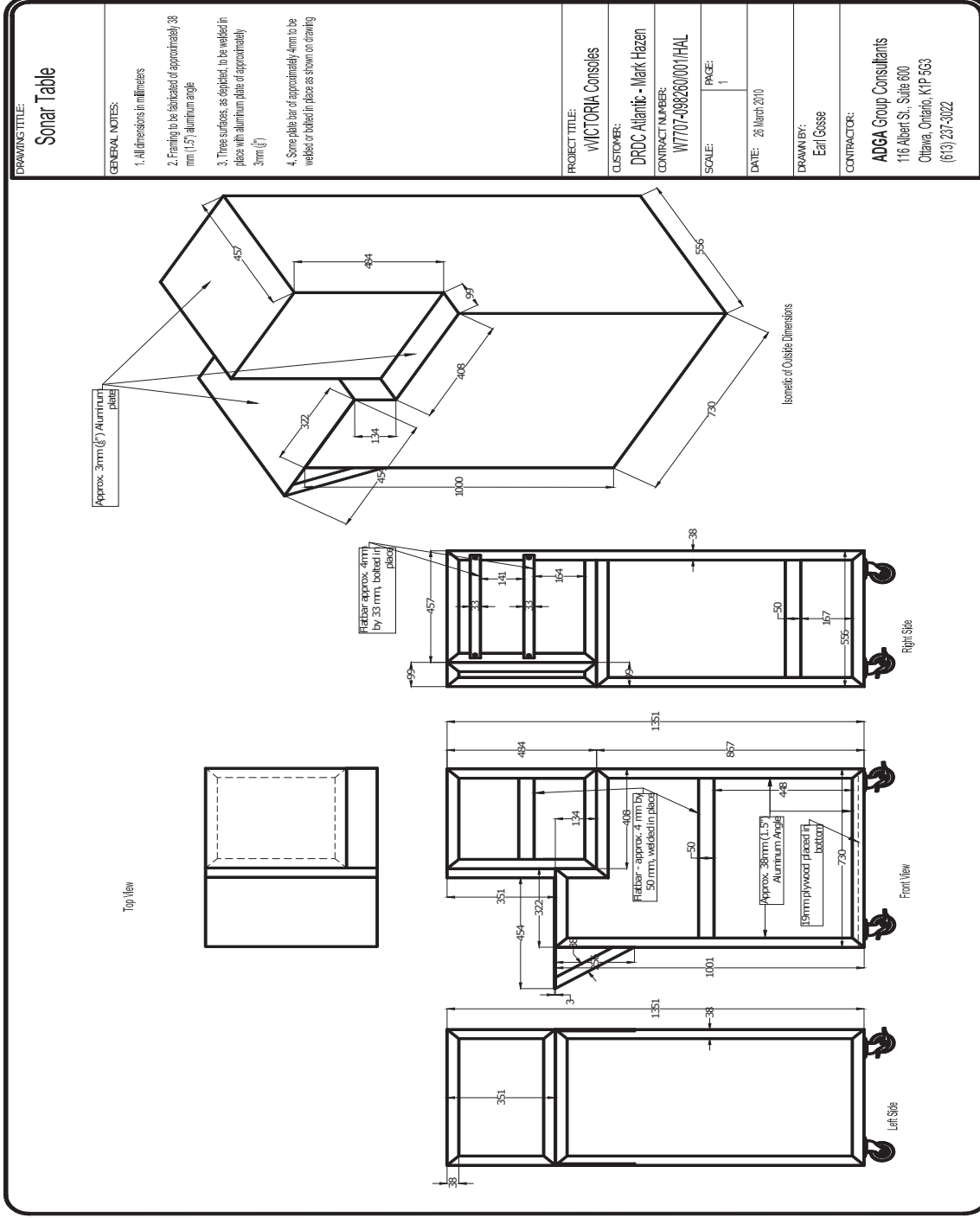
DATE: 30 March 2010

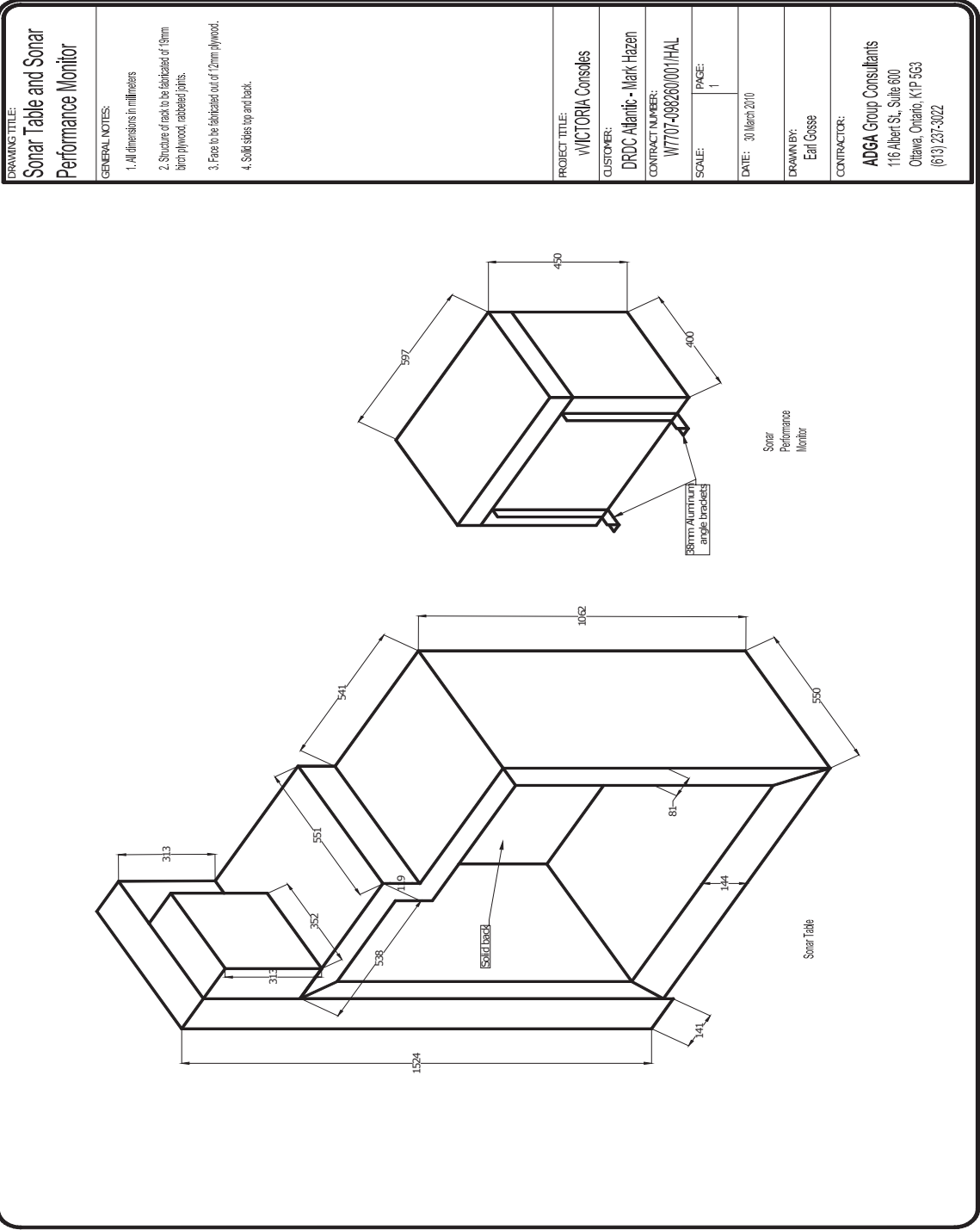
Front view

Side view









Annex B Component Listing

This annex is a simplified copy of the Excel spreadsheet supplied to DRDC on a CD. That spreadsheet contained more information in a better organized format and also included websites for each item.

Multifunction Display

Item	Description	Manufacture	Part		Source	Cost Per Unit	Num		Notes
			Number	Req			Req	Unit	
1	Power Bar	ultra 7	u12-40629		tiger direct	\$ 22.99	1	CAN	
2	AC Receptacle	Qualtek Electronics corp	703W-00/08		Digi-Key (pg1619)	\$ 1.08	1	US	ac power input
3	Power on/off switch Terminal Block	Tyco Electroics	PRDDA1-16F-BB000		Digi-Key (pg2176)	\$ 3.28	1	US	Main power on/off switch
4	Power	Tyco Electroics	1546670-4		Digi-Key (pg366)	\$ 1.51	1	US	Main power on/off switch
						\$			cct
5	Trackball	Storm Interface	2200-000203		Digi-Key (pg2179)	132.90	1	US	USB output
						\$			
6	Keyboard	CTI Electronics	K16800		Stealth Computer	325.00	1	US	can be ordered with usb
7	Fan (TernalPro)	Comair	MU2B1		Digi-Key (pg2490)	\$ 56.22	1	US	Variable speed cooling fan
8	Fuse Holder	LitteFuse	03420022H		Digi-Key (pg2128)	\$ 4.54	1	US	Inline Fuse for Fan unit
		Qualtek Electronics corp	08141		Digi-Key (pg2491)	\$ 2.02	1	US	For fan safety
10	Busser (Sonalert)	multicorp	mckpi-g4211l-3673		newark	\$ 1.55	1	can	Replacement for speaker
11	USB Plug Ethernet RJ45	switchcraft	14b		newark	\$ 5.75	1	CAN	USB from back panel to hub
12	panel F to M	samtec	scre-01		newark	\$ 9.33	1	CAN	Ethernet to computer if required
13	USB Hub	solidtek	s144-1064		tiger direct	\$ 35.99	1	CAN	7 port output
	Power indicator								
14	lamp	APEM Components	Q14F1BXXR110E		Digi-Key (pg2711)	\$ 14.00	1	US	Power on lamp
15	audio socket	Switchcraft	12B		Digi-Key (pg487)	\$ 3.60	2	US	headset plug
16	audio socket cover	Switchcraft	515X		Digi-Key (pg487)	\$ 11.81	2	US	headset plug cover
17	push switch	idec	la2l-a1c64-r		newark	\$ 24.43	2	can	SQ switch for top unit (fire SW)
18	Protective cover	NKK Switch	AT494		Digi-Key (pg2231)	\$ 2.84	2	US	cover for switch (fire SW)

19	Key Switch	APEM Components	jd75090	newark	\$ 14.12	can	1	
20	Optical Encoder side payboard mounted encoder	CIU INC	C14D32P-B3	Digi-Key (pg2274)	\$ 31.38	US	4	TMA solutions encoder
21	knob	Ohmite	5150E	Digi-Key (pg2048)	\$ 31.43	US	4	for TMA solutions encoder
22	indicator lamp	APEM Components	Q8P1BXXR110E	Digi-Key (pg2711)	\$ 11.63	US	2	power available
23	3' caster (Swivel)	Shepherd	8479	Home Depot	\$ 8.95	can	3	rear units
24	3' caster with brake (Swivel)	Shepherd	9511	Home Depot	\$ 10.97	can	3	front units
	wire	i/o interconnect	H0081R-X-ND	Digi-Key (pg311)	\$ 33.93	us	1	will depend on what is to be connected
	wire	i/o interconnect	H0041R-X-ND	Digi-Key (pg311)	\$ 55.20	us	1	will depend on what is to be connected
	wire	alphaWire	1858/19 005	Digi-Key (pg2345)	\$ 90.10	us	2	will depend on what is to be connected
	Cable markers	pandquit	tc-4c	Digi-Key (pg2404)	\$ 37.51	us	1	
	terminals	3M	94771	Digi-Key (pg380)	\$ 12.36	us	3	units of 100
	terminal strips	Tyco Electronics	1-601805-1	Digi-Key (pg366)	\$ 7.68	us	3	80 Spaces/ unit
	Tie Wraps	AutomationDirect	BMB-B1625	AutomationDirect	\$ 1.25	us	3	units of 100
	Cable tie mount	AutomationDirect	BM-B0903	AutomationDirect	\$ 6.25	US	1	units of 100
	shop supplies							3/4 inch ss pan head screws
	Labour							etc

Sonar 2046

	<i>Item</i>	<i>Manufacture</i>	<i>Part Number</i>	<i>Source</i>	<i>Cost Per Unit</i>	<i>Num Re q</i>	<i>Notes</i>
1	CO2 insertion point						
2	Power Bar	Hammond Manufacturing	1584H6A1	Hammond Manufacturing	\$ 1.08	1	EMI/RFI Filtration
3	ac receptacle	Qualtek Electronics corp	703W-00/08	Digi-Key (pg1619)	\$ 14.00	1	ac poiwer input
4	indicator led	APEM	Q14F1BXXR110E	Digi-Key (pg2711)	\$ 5.47	2	Main power on/off switch
5	Power on/off switch Terminal Block	e Switch	RVW42D1100=116	Digi-Key (pg2206)	\$ 1.51	1	Main power on/off switch cct
6	Power	Tyco Electroics	1546670-4	Digi-Key (pg366)	\$132.90	1	USB output
7	Trackball	Storm Interface	2200-000203	Digi-Key (pg2179)	\$ 14.00	1	Cable for trackball
8	USB Trackball Cable	Storm Interface	2200-003003	Digi-Key (pg2179)	\$ 56.22	1	
9	Fan (TtermalPro)	Comair	MU2B1	Digi-Key (pg2490)	\$ 4.54	1	Fuse for Fan unit
10	fuse holder	LittleFuse Qualtek	03420022H	Digi-Key (pg2128)	\$ 2.02	1	
11	Fan Guard	Electronics corp	08141	Digi-Key (pg2491)	\$ 26.45	1	USB from back panel
12	Busser (Sonalert)	Mallory	SC416	Digi-Key (pg2362)	\$ 10.00	1	to hub
13	USB Plug Ethernet RJ45 panel	Fontx	P1011	Fontx	\$ 13.07	1	
14	F to M	Fontx	P115-036	Fontx	\$ 41.99	1	4 port output
15	USB Hub	Ergeton	97-499-085	CDW	\$137.21	16	
16	Pushbutton switch	Honeywell		allied electric	\$ 8.95	2	rear units

17	3' caster (Swivel)	Shepherd	8479	Home Depot	\$ 10.97	can	2	front units
18	3' caster with brake (Swivel)	Shepherd	9511	Home Depot	\$ 12.55	US	1	
19	daylight/night switch	OMRON	A165-TRM-1	Digi-Key (pg2362)			2	Cannot source
20	intercom plug							
	wire	i/o interconnect	H0081R-X-ND	Digi-Key (pg311)	\$ 33.93	us	1	will depend on what is to be connected
	wire	i/o interconnect	H0041R-X-ND	Digi-Key (pg311)	\$ 55.20	us	1	will depend on what is to be connected
	wire	alphaWire	1858/19 005	Digi-Key (pg2345)	\$ 90.10	us	2	will depend on what is to be connected
	terminals	3M	94771	Digi-Key (pg380)	\$ 12.36	can		units of 100
	terminal strips	Tyco Electronics	1-601805-1	Digi-Key (pg366)	\$ 7.68	can		80 Spaces/ unit
	Tie Wraps	AutomationDirect	BMB-B1625	AutomationDirect	\$ 1.25	us		units of 100
	Cable tie mount	AutomationDirect	BM-B0903	AutomationDirect	\$ 6.25	US		units of 100
	shop supplies							3/4 inch ss pan head screws etc

Sonar 2046 Display 4

	<i>Item</i>	<i>Manufacture</i>	<i>Part Number</i>	<i>Source</i>	<i>Cost Per Unit</i>	<i>Num Req</i>	<i>Notes</i>
1	Power Bar	Hammond Manufacturing	1584H6A1	Hammond Manufacturing	\$ 48.65	1	EMI/RFI Filtration
2	ac receptacle	Qualtek Electronics corp	703W-00/08	Digi-Key (pg1619)	\$ 1.08	1	ac poiwer input indicators next to power on/off sw
3	indicator led	APEM	Q14F1BXXR110E	Digi-Key (pg2711)	\$ 14.00	2	Main power on/off switch
4	Power on/off switch Terminal Block	e Switch	RVW42D1100=116	Digi-Key (pg2206)	\$ 5.47	1	Main power on/off switch cct
5	Power	Tyco Electroics	1546670-4	Digi-Key (pg366)	\$ 1.51	1	
6	Fan (TtermalPro)	Comair	MU2B1	Digi-Key (pg2490)	\$ 56.22	1	
7	fuse holder	LitteFuse Qualtek	03420022H	Digi-Key (pg2128)	\$ 4.54	1	Fuse for Fan unit
8	Fan Guard	Electronics corp	08141	Digi-Key (pg2491)	\$ 2.02	1	
9	Busser (Sonalert)	Mallory	SC416	Digi-Key (pg2362)	\$ 26.45	1	USB from back panel to hub
10	USB Plug	Fontx	P1011	Fontx	\$ 10.00	1	
11	Eathernet RJ45 panel F to M	Fontx	P115-036	Fontx	\$ 13.07	1	
12	USB Hub	Ergeton	97-499-085	CDW	\$ 41.99	1	4 port output
13	3' caster (Swivel)	Shepherd	8479	Home Depot	\$ 8.95	2	rear units
14	3' caster with brake (Swivel)	Shepherd	9511	Home Depot	\$ 10.97	2	front units
	wire	i/o interconnect	H0081R-X-ND	Digi-Key (pg311)	\$ 33.93	2	will depend on what is to be connected

wire	i/o interconnect	H0041R-X-ND	Digi-Key (pg311)	\$ 55.20	us	2	will depend on what is to be connected
wire	alphaWire	1858/19 005	Digi-Key (pg2345)	\$ 90.10	us	2	will depend on what is to be connected
terminals	3M	94771	Digi-Key (pg380)	\$ 12.36	can	3	units of 100
terminal strips	Tyco Electronics	1-601805-1	Digi-Key (pg366)	\$ 7.68	can	3	80 Spaces/ unit
Tie Wraps	AutomationDirect	BMB-B1625	AutomationDirect	\$ 1.25	us	2	units of 100
Cable tie mount	AutomationDirect	BM-B0903	AutomationDirect	\$ 6.25	US	1	units of 100
shop supplies							3/4 inch ss pan head screws etc
Labour							

OMC

<i>Item</i>	<i>Manufacture</i>	<i>Part Number</i>	<i>Source</i>	<i>Cost Per unit</i>	<i>Num Req</i>	<i>Notes</i>
Indicator						
1 lamp/SWITCH	Honeywell	Honeywell series 2	allied electric	\$137.21	us 412	numbers will be determined by type installed
Barrier mount short						
1a side	Honeywell	2c207/2c209	allied electric	\$ 63.76	us	numbers will be determined by type installed
Barrier mount long						
1b side	Honeywell	2c210/2c203/2f203	allied electric	\$65.78	us	numbers will be determined by type installed
mounting barriers						
1c long side	Honeywell	2b4	allied electric	\$ 8.07	us	numbers will be determined by type installed
mounting barriers						
1d short side	Honeywell	2b3	allied electric	\$ 8.07	us	numbers will be determined by type installed
toggle switch	C & K	T102SHXQE	DIGIKEY (PG 2183)	\$ 8.30	us 17	
Knob (Switch)	NKK Switches	AT431	DIGIKEY (PG 2183)	\$ 6.08	us 30	
indicator led	APEM	Q14F1BXXR110E	Digi-Key (pg2711)	\$ 14.00	us 2	
CO2 fire ext fitting					4	Can not source
round knobs	electroswitch					
USB 6 Digit Numeric Display	electronic	1914N	Digi-Key (pg2711)	\$ 10.88	us 7	
3' caster (Swivel)	DELCOM		DELCOM			
3' caster with brake (Swivel)	PRODUCTS INC	806016	PRODUCTS INC	\$67.20	us 1	
	Shepherd	8479	Home Depot	\$ 8.95	us 5	rear units
	Shepherd	9511	Home Depot	\$ 10.97	us 5	front units
Red Indicator	Omrion Electronics Inc-IA Div	M16-TR-5D	Digi-Key (pg???)	\$ 10.73	us 1	

Busser (Sonalert)	Mallory	SC416	Digi-Key (pg2362)	\$ 26.45	US	1	May require a cover to be supplied
4 digit display (usb)	DELCOM Products	806004	DELCOM Products	\$ 58.90	us	8	May require a cover to be supplied
6 digit display (USB)	DELCOM Products	806006	DELCOM Products	\$ 60.90	us	1	May require a cover to be supplied
8 digit display (USB)	DELCOM Products	806008	DELCOM Products	\$ 65.10	us	1	May require a cover to be supplied
emergency compass						1	Can not source
compass repeater						1	Can not source
8' x8' display						1	Can not source
1" DISPLAYS						15	
2" DISPLAYS (GRAY)						25	
2 1/2" DISPLAYS (BLACK)						12	
SLIDING SWITCHED						2	Can not source
wire							
terminals	3M	94771	Digi-Key (pg380)	\$ 12.36	can		units of 100
terminal strips	Tyco Electronics	1-601805-1	Digi-Key (pg366)	\$ 7.68	can		80 Spaces/ unit
Tie Wraps	AutomationDirect	BMB-B1625	AutomationDirect	\$ 1.25	us		units of 100
Cable tie mount	AutomationDirect	BM-B0903	AutomationDirect	\$ 6.25	US		units of 100
shop supplies							will depend on what is to be connected

List of symbols/abbreviations/acronyms/initialisms

DND	Department of National Defence
DRDC	Defence Research & Development Canada
DRDKIM	Director Research and Development Knowledge and Information Management
R&D	Research & Development

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This work describes the development of emulation designs of the Combat System equipment consoles currently fitted in the control room area of the VICTORIA Class submarines and the subsequent manufacture of the console emulations in accordance with those designs. Physical data and specifications of the actual consoles were gathered and emulations, to be constructed of wood, plastics and light metals, were designed based on that data. After DRDC Atlantic approval of the designs, the construction of the console emulations were completed as designed. This work will enable the vVictoria capability evaluation laboratory to move toward successful set-up and readiness to conduct experimentation on facets of new Combat System concept development including equipment capabilities, system integration, optimum equipment configurations and human factors.

Le présent rapport porte sur le développement et la fabrication de modèles d'émulateurs des consoles de systèmes de combat actuellement installées dans la salle de contrôle des sous-marins de classe VICTORIA. Les émulateurs, faits de bois, de plastiques et de métaux légers, ont été fabriqués selon les données matérielles et les spécifications des consoles actuelles. RDDC Atlantique a approuvé les modèles, et ces derniers ont servi à la fabrication des émulateurs de console. Les présents travaux permettront la mise sur pied du laboratoire d'évaluation de la capacité vVictoria et assureront que celui-ci est prêt pour les essais de nouveaux concepts de système de combat, visant notamment les fonctions de l'équipement, l'intégration du système, les configurations optimales du système et les facteurs humains.

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Victoria; console; emulation

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